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10/520810

DT15 Rec'd PCT/PTO 10 JAN 2005

INTERMEDIATE CIRCUIT CAPACITOR SHORT-CIRCUIT MONITORING

The present invention relates to an electronic circuit for short-circuit monitoring of one of at least two series-connected intermediate-circuit capacitor units, according to Claim 1.

Monitoring of this type is required when a plurality of capacitors is connected in series, to achieve a certain voltage sustaining capability. Converters that are connected directly to a 3-phase network operate with an intermediate-circuit voltage of approximately 750 V. Economical capacitors usually have a maximum voltage sustaining capability of 450 V, however. As a result, to obtain the necessary voltage sustaining capability, at least two capacitors of this type must be connected in series. The series-connected capacitors are always connected in parallel with the intermediate circuit.

Modern converters in the low to moderate performance class function according to the PWM (pulse-width modulation) principle, which results in high switching current frequencies and alternating current frequencies in the intermediate circuit. The currents which are therefore produced subject the capacitors to a high thermal load. In the extreme case, this load can result in an at-first undetected short circuit in one of the series-connected elements. The missing capacitance results in an overloading of the remaining capacitors and, possibly, a risk of fire.

The object of the present invention is to provide a simple monitoring system that is capable of quickly detecting a short circuit in one of a plurality of series-connected capacitor units, whereby a unit can be composed of one or more capacitor(s) connected in any fashion. The system should be able to signal a short circuit to a higher-order control system, and it must be robust enough to withstand high voltages, high temperatures and strong electromagnetic interferences.

This object is attained by the features of Claim 1. An advantage of the wiring according to the present invention is that the monitoring is carried out using a simple voltage comparison, whereby the difference between the voltage present at the junction between two of the capacitor units to be monitored and a reference voltage that is relevant for the monitoring and is shunted from the intermediate-circuit voltage is used as the control signal, which, if the capacitor short circuits, falls below or exceeds a response threshold and generates an error signal. The state of the error signal is monitored by the drive computer or a higher-order control unit. If an error occurs, the relevant error reaction is carried out. As an alternative or in addition, the error can also be displayed using a display means, e.g., a light-emitting diode on the drive.

Preferred embodiments of the present invention are indicated in the dependent claims.

An advantage of the present invention is that the capacitors are either monitored individually, or they can be connected in parallel or in series to form units that can be treated and monitored as individual capacitors. The units can then be adapted exactly to the requirements of the converter.

In a preferred embodiment, the required reference voltage is generated from a chain of series-connected resistors, the chain being connected in parallel with the units to be monitored. The voltage divider created in this manner ensures that voltage fluctuations, which are common in an intermediate circuit, are automatically mirrored by the reference signal and are therefore compensated for. The capacitor monitoring is indifferent with regard for voltage fluctuations of this type.

In a further preferred embodiment, the response threshold which is relevant for the system is established by the breakdown voltage of a zener diode. The zener

diode ensures that electronic disruptions do not result in an undesired triggering of the error signal.

To insulate the error signal voltage from the zero volt potential of the intermediate-circuit voltage, an error signal voltage is generated using a current-voltage converter directly from the current that flows due to the voltage asymmetry produced when an error occurs.

A further advantage of the present invention lies in the fact that the error signal-generating current is limited by the chain of resistors required to generate the reference voltage. The resistors have two separate functions for this reason, and are optimized for both of them simultaneously. This results in a reduction in the number of components.

In a further preferred embodiment, an element corresponding to each capacitor unit is provided in the chain of resistors, whereby an element is composed of one or more resistors. The individual capacitor units are monitored in this manner.

In a further preferred embodiment, the ratio of capacitor capacitance (in farads) to the corresponding part of the chain of resistors is essentially the same for all pairs of corresponding resistor parts and capacitors. This ensures that the electrical potential difference which exists in the normal state between the junctions between two of the capacitors to be monitored, and that which exists in the normal state at the junction between the two corresponding parts of the chain of resistors does not exceed a predefined threshold.

In a further preferred embodiment, the error signal voltage is free of ground potential. The advantage of this is that the error signal voltage can be allotted to any ground potential.

In a further preferred embodiment, the error signal voltage is generated using a light-emitting diode-insulated transistor. For this reason, the error signal voltage is galvanically separated from the high voltage to be monitored. Opto-insulating components are reliable and easy to install, in contrast to magnetic components.

In a preferred embodiment, all capacitor units to be monitored have the same capacitance. This simplifies the circuit and the selection of resistors corresponding to the capacitors. To further reduce the fabrication cost and simplify the circuit, every part of the chain of resistors is composed of a resistor.

In a further preferred embodiment, the number of capacitor units to be monitored is equal to two. The advantage of this embodiment is that the complexity of the circuit is minimized.

In a further preferred embodiment, every capacitor unit is composed of one capacitor, which results in further simplification of the circuit.

An exemplary embodiment of the present invention is shown in Figure 1 and will be described in greater detail below.

Figure 1 shows a schematic illustration of the intermediate-circuit bus (10, 11) of a frequency converter, including two series-connected capacitors (1, 2) and the monitoring circuit (16) according to the present invention. Figure 2 shows an example of an intermediate-circuit bus with a plurality of series-connected capacitors (1) and their associated monitoring units (19). In Figure 1, the capacitors (1, 2)—considered together—have an increased voltage sustaining capability, which corresponds to the sum of the two rated voltages, but have reduced capacitance, in accordance with Kirchhoff's voltage law. If the reduced capacitance is not adequate and larger capacitors (1, 2) with the required voltage sustaining capability are not available, further capacitors can be connected in

parallel, to increase overall capacitance. In this example, the intermediate-circuit voltage is equal to the difference between $L_{(+)}$ (10) and $L_{(-)}$ (11).

The monitoring circuit (16) is preferably composed of two series-connected resistors (3, 4), four diodes (5), (6), (7), (8), a zener diode (15), and a galvanically-insulated output (12). In this case, the galvanic insulation (9) is realized by a combination of a light-emitting diode and a light-sensitive transistor, the transistor including an open collector output (12). Diodes (5) and (6), and (7) and (8) are connected in series, whereby the cathode of diodes (5) and (8) is connected to the anode of diodes (6) and (7). The two diode pairs are then connected in parallel, so that the cathodes of diodes 6 and 7 are connected with each other, and the anodes of diodes (5) and (8) are connected with each other. The connection between diodes (5) and (6) is connected to the capacitor voltage to be measured. The connection point between diodes (7) and (8) is connected to the reference voltage.

The cathode of the zener diode (15) is connected to the cathodes of diodes (6) and (7), and its anode is connected, with reverse polarity, to the cathode of the light-emitting diode of the optical insulating component. The cathode connection of the insulating component is connected with the anodes of diodes (5) and (8).

Since the capacitors (1, 2) and resistors (3, 4) all have a voltage-dividing function, half—at first approximation—of the intermediate-circuit voltage is present, in normal operation, at the two junctions (14) and (13), i.e., the voltage difference between junctions (14) and (13) is nearly zero. In this state, no current flows between the two junctions.

Since both voltages form the same linear function of the intermediate-circuit voltage, and since only the differential voltage is relevant, negative effects that would be expected due to the noise and voltage fluctuations that often occur in the intermediate-circuit bus are eliminated.

When a capacitor (2, 1) short circuits, a differential voltage forms between junctions (13) and (14). When this differential voltage exceeds a predefined threshold that corresponds to the sum of two diode voltages (7, 5) or (6, 8) plus the zener diode (15) breakthrough voltage, current flows. The circuit is designed so that current always flows through the zener diode (15) in the same direction, independently of whether the voltage at junction 13 is greater than or less than the voltage at junction 14.

The current resulting from the voltage asymmetry switches the transistor (9) on, thereby activating the error signal (12). The strength of the current is limited by the size of the resistor (3) and/or (4). Since the properties of zener diodes and light-emitting diodes are dependent on the current intensity, the components must be designed such that a rapid response by the error signal (12) is ensured. When a plurality of capacitors (1, 2) is connected in series, then, to ensure that the individual capacitors are monitored, the monitoring circuit must be present in plurality, i.e., an additional monitoring circuit must be installed for each additional series-connected capacitor. This is shown in Figure 2, whereby the 4 capacitors (1) are monitored by 3 monitoring units (19). One error signal output (12), one reference voltage input (14) and an associated capacitor voltage input (13) are provided for each unit. Activation of an error signal (12) is still caused by a capacitor short circuit (1), whereby the short-circuiting of a capacitor (1) can trigger one or more error signals (12). All error signals (12) should be monitored so that, if a short circuit occurs, it is possible to determine exactly which capacitor (1) has failed.

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Reference Numerals

1. Capacitor
2. Capacitor
3. Capacitor
4. Capacitor
5. Diode
6. Diode
7. Diode
8. Diode
9. Galvanic insulation
10. Negative intermediate-circuit voltage
11. Positive intermediate-circuit voltage
12. Error signal
13. Junction
14. Reference voltage measurement point
15. Zener diode
16. Monitoring circuit
17. Light-sensitive diode
18. Light-sensitive transistor
19. Monitoring unit